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INPUT-OUTPUT ANALYSIS IN ECONOMIC THEORY AND HISTORY

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N O T A

La Unidad de Investigaciones Económicas publica el presente trabajo del Dr. Angel L. Ruiz Mercado, "Input-Output Analysis in Economic Theory and History" en su Serie de Temas Diversos de Economía. En el mismo, el Doctor Ruiz hace una breve exposición de la relevancia y objetivos de la técnica de insumo-producto en el análisis económico. En su opinión, la técnica de insumo-producto desarrollada por W. Leontief es un modelo macroeconómico de equilibrio general, el cual resuelve el problema de estimación empírica inherente a los modelos de equilibrio general previos, a-la-Quesnay-Walras-Pareto. La técnica insumo-producto combina, según lo expone el Doctor Ruiz, el análisis econométrico, teórico, matemático y estadístico. Su objetivo principal es el estimar empíricamente las interrelaciones existentes entre las diferentes actividades económicas.

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INPUT-OUTPUT ANALYSIS IN ECONOMIC THEORY AND HISTORY

* By Angel Luis Ruiz, Ph.D.

Modern macro-economic thinking has been dominated by two general equilibrium systems, the Keynesian and the Leontief's input-output systems. Although presented as an alternative to the "classical" economics, Keynesian economics drew on the work of both classical and neo-classsical economists. Both neo-classical and Keynesian economists were interested in the forces determining equilibrium, or desequilibrium. However Keynes struck a major blow on the classical system by placing employment determination at the center of his system and reducing price determination to a secondary role. His system, like the classical system, emphasizes the economy as a whole. Therefore it could be classified as a macro general equilibrium system as opposed to the neo-classical partial equilibrium system. Leontief's system was an attempt to make Walrasian concept of general interdependence empirically manageable [1]. Leontief defines input-output as "an adaptation of the neo-classical theory of general equilibrium to the empirical study of the quantitative interdependence between interrelated economic activities" [2].

Theoretical explanation in the area of interdependence began more than two centuries ago with the works of a French economist, Francois Quesnay. His most famous book The Tableau Economique, was published in 1758 and was acclaimed by some people as one of the greatest contributions to the Physiocratic School of Thought [3]. For Quesnay, as for all physiocrats, his economics was really a corollary of something much larger. The foundations of his economic thought was to be found in his view of

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natural and positive law, to his conception of the "rule of nature", to which the Physiocratic School owes its name. It can safely be asserted that Quesnay was really the founder of modern political economy. According to him, as well as his followers, problems concerning the nature of wealth, the conditions of its production and the laws of its distribution were matters to which scientific and empirical reasoning may be applied with the objective of arriving at universal truth [4]. Some other economists, however, think that the Tableau should not be considered as a centerpiece of Physiocratic system. According to one author, what it achieved was a vivid graphic picture of general interdependence by means of drastic simplification of the economic system into three interacting sectors [5]. Recognition that Quesnay was one of the most important pioneers of interindustry accounting and analysis was given by the person who years later became one of the greatest contributor to this type of analysis. W. Leontief introduced Part 1 of his classic book by mentioning that "the statistical study presented in the following pages may be best defined as an attempt to construct a Tableau Economique of the United States for 1919 and 1929 [6].

The next step in the evolution of the concept of economic interdependence had to wait more than a hundred years. In 1874 Leon Walras published the first part ("The Theory of Exchange") of his book Elements d'Economie Politique Pure. The second part ("Theory of Production") was published in 1877. Walras was the first to conceive the concept of general economic equilibrium, as opposed the method called partial equilibrium approach related to the names of Alfred Marshall and other English-speaking economists. The general equilibrium method became the focus of attention of The Lausanne School where Walras obtained a position in 1870. Together with Stanley Jevons and Carl Menger, he was the founder of the modern subjective Theory of Value. This Theory is based upon the assumption of the primary importance

of the subject, in this case man. It begins with the idea that scarcity, "rarete", is a function of desire. Value is a matter of preference between objects of desire - positive desires, and is identical with prices: a preference is a pricing process, a ratio between one good and another. Thus the idea of "mutual determination" arises.[7] Unlike other economists of the neo-classical school, Walras was interested in the simultaneous determination of all prices. However his interest went further to explore the conditions for general equilibrium of production[8]. The problem of production fell in two parts: (1) The one related to the factors of production, which are used in combination with one another and (2) the role of time in production - The Theory of Capital. According to Hicks the first problem is really an extension of the Theory of Value: "it studies one particular kind of interrelation of prices". Walras devoted his attention to the case where the "coefficients of production" are fixed, so that the quantity of all factors needed to produce a unit of each kind of finished goods are technically given. In other words, the coefficients were determined by technology and they measured the factors of production needed to produce a unit of finished goods. Given the conditions of fixed coefficients and perfect competition, the equilibrium prices of the products must depend on the prices of the factors; thus, given the prices of the factors, the whole price system (of products and factors) can be derived by addition. But, given this whole price-system, the demands for products and the supply of factors can be determined from the tastes and abilities of the individuals composing the economy.[9]

Although Walras General Equilibrium Model was a brilliant theoretical work it was empirically unworkable. Meanwhile, the "Grand System of Economics" developed and perfected by The Neoclassical School was being challenged by the historical conditions prevailing in the late twenties and thirties. A

purely theoretical frame without the empirical compliment is as useless as the process of pure collection of data without theory. Leontief, writing at the beginning of the fifties, discussed the matter in one article for the Scientific American.[10] According to him "we have in economics today a high concentration of theory without fact on the one hand, and a mounting accumulation of fact without theory on the other". In other words, while theoreticians were busy with the creation of more empty boxes and gaining expertise in implicit theorizing, the empiricists were using more and more sophisticated statistical tools in their measurement without theory. Leontief baldly chalked out a practical programme aimed at the fusion on the two.[11] Leontief not only developed a theory of production based on the concept of interdependence but also gave to his theory empirical content publishing an input-output table for the American Economy in 1936.[12] However, Leontief's work on this subject, at Harvard University, dates back to 1931. Thus Leontief rescued Quesnay-Walras-Pareto Theory from describing a static general equilibrium by providing a format for examining the interdependent structure of an observable economy. In Dorfman words, what Leontief did was to simplify Walras generalized model to the point where the model's equations could be estimated empirically.[13]

In order to make his general equilibrium model empirically manageable Leontief had to resort to certain simplifications. First the large number of commodities in Walras's model had to be reduced into relatively few output, one for each industry - each industry produce its own characteristic product and no other. In addition each product is uniform. In other words there should exist product homogeneity. The most important assumption in Leontief model, however, is that each input is required in a fixed ratio to the output into which it enters, a ratio which is independent of the levels of that output. An instantaneous economy, he assumed, can have only

fixed coefficients and any change in the data in the short-term would not lead to process substitution.[14] "A large number of phenomena, which in economic discussions are referred to as instances of factor substitution, prove upon closer examination to conceal the non-homogenous character of conventional industrial classification".[15] According to one author the constant and linear production solves all kind of difficulties: for instance, it gets rid of factor substitution and economies of scale, but it creates others. Time is missing, yet the purchase of inputs by one industry to make goods to sell to other industries implies a period analysis. However, many of the problems associated with the above mentioned assumptions are more than offset by the multiple advantages inherent in this type of model. Time dimension, for instance, can be taken care of by using dynamic input-output analysis - by transferring the capital creation part of the model from the final demand to the internal structure of the inputs.

Today input-output analysis constitutes one of the most important branch of economics. As part of econometrics it combines theoretical, mathematical and statistical analysis. It is widely used both in highly developed countries as well as in many countries in process of development. Many input-output tables have been constructed by the U.S.A. Department of Commerce, the latest official one being that for the year of 1972.[17]

In the United Kingdom early work started in 1948 led to the construction of 1954 table. At present there are tables for the years 1963, 1967 and 1974.[18] At present many other European countries have constructed input-output tables. Among them we find Holland, Spain, Germany, Norway, France and many other in Western as well as in the Eastern part of Europe. In Latin America, countries like Mexico, Colombia, Costa Rica, Argentina, Cuba and Puerto Rico are among those with input-output tables. Of these the latter country, Puerto Rico, has been the most proliferous with input-

output tables for the years 1949, 1960, 1963, 1967, 1972, the latest being a table of 336 commodities by 93 industrial sectors for the year 1977.[19/]

Another country where input-output analysis have attained high levels of prominence is India. Although the preparation of an input-output table began in 1954, by the Indian Statistical Institute, there already existed rudimentary tables for the years 1948-49 and 1950-51.[20/]

Several reasons have accounted for the wider acceptance of input-output economics. Due to its "value free" nature it has been widely used as analytical tool in countries with planned economies as well as in those countries which rely mainly on the market mechanism.[21/] Its great flexibility enable it to be applied to the clarification or solution of problems within different branches of economics. Its application have covered such fields of economics as International Trade, Economic Planning, Regional Economic Analysis, Price Theory, Economic Forecasting and others.[22/]

Some theoretical developments after Leontief's pioneer work has also helped to generalize the input-output model. In 1951 Samuelson, Koopmans and Arrow showed that, given certain assumptions, substitution could be introduced in the I-O model, thus giving it more generality and acceptance.[23/] In the long run the most important development was the development of input-output cum linear programming models. Both techniques are closely related. The use of linear programming can convert an input-output model into an optimization procedure eliminating some of the restrictions of the simple input-output model.[24/]

Two additional developments of more recent origin merit mentioning as relatively "new" applications of input-output analysis. One is the possibility of integrating economics and ecological models in input-output framework. Writers like Cumberland, Daly, W. Isard, and Leontief have each suggested that input-output models can be adapted to incorporate environmental

sectors. These latter writers have emphasized empirical aspects of the problem, while writers like Ayres and Kneese have devoted themselves to a theoretical revision of Walras-Cassel general equilibrium model to adapt it to satisfy the Law of Conservation of Mass which is fundamental to the investigation of economics and its interrelation with the environment.[25/] The other development is the use of commodity-by-industry input-output models. These type of models have been used by Canadian economists (especially those connected with Canada's Dominion Bureau of Statistics - DBS). According to Victor until recently input-output analysis and inter-industry analysis have been synonyms for each other. However, in commodity-by-industry analysis commodities and industries both enter explicitly, and the need to aggregate the multicommodity output of each industry into composite commodity is avoided. Full recognition is then given to the fact that each industry uses and produces many commodities and that some commodities are produced by more than one industry. [26/]

The commodity-by-industry analysis requires the availability of input-output tables by commodities. In the United States, Puerto Rico and other countries (i.e. Canada, G.B.) these tables are available. In future works, we will use the Puerto Rican Input-Output table to illustrate commodity-by-industry accounting and models.

FOOTNOTES

1/ As Miernyk points out, "Neither the neo-classical nor the Keynesian were directly concerned with economic interdependence, with the structure of the economy and the way in which its individual sectors fit together". See W.H. Miernyk, The Elements of Input-Output Analysis, Random House, New York (1965) Chapter 1.

2/ W. Leontief, Input-Output Economics, Oxford University Press, New York (1966), No. 7.

3/ For instance, Marquis de Mirabeau declared it to be one of the three greatest discoveries since the world began an K. Marx, writing about the Tableau, opined that "Never before had thinking in political economy reached such heights of genius". Both quoted in Almarin Phillips "The Tableau Economique as a Simple Leontief Model", Quarterly Journal of Economics, February 1955 (original quotes were in Adam Smith, The Wealth of Nations, Cannan Edition; II 177 n, and K. Marx, A History of Economic Theories (Kar Kautsky ed.), N. Y. 1952.

4/ Sir Alexander Gray, The Development of Economic Doctrines, An Introductory Survey, John Wiley and Sons Inc., New York, Chapter 4; Lewis H. Haney, History of Economic Thought, MacMillan Company, N. Y. , Chapter 9; J. A. Schumpter, History of Economic Analysis, Oxford University Press, New York, 1954.

5/ M. Blaug, Economic Theory in Retrospect, Richard D. Irwin, Inc., Illinois, page 26.

6/ W. Leontief, The Structure of the American Economy, 1919-1939; Oxford University Press, New York, 1951, page 9.

7/ H.W. Spiegel (editor), The Development of Economic Thought, John Wiley and Sons, Inc., New York, pages 580-591 ("Hicks on Walras"). See also Lewis H. Haney, op.cit, pages 781-802.

8/ This part of the analysis follows Hick's article as a reference.

9/ According to Hicks it was really a pity that Walras did not trouble to work out cases where coefficients were variable, although he was quite aware of the case. An extension of Walras analysis to include cases with variable coefficients "would have led directly to the general law of Marginal Productivity", Hicks, op.cit, page 587.

10/ The article has been reproduced in his book Input-Output Economics, Oxford University Press, New York (1966), Chapter 2.

11/ P.N. Mathur, "Introduction" to A. Carter and A. Brody (ed.), Contributions to Input-Output Analysis, Vol. I, North Holland Publishing Co., Amsterdam, 1970.

12/ W. Leontief, "Quantitative Input-Output Relations in Economic System of the United States", The Review of Economic And Statistics (August 1936).

13/ R. Dorfman, "The Nature and Significance of Input-Output", Review of Economics and Statistics (1954).

14/ A. Kundu, P.N. Mathur, G.S. Bhalla and K.S. Chalapati Rao, Input-Output Framework and Economic Analysis, Center for Study of Regional Development, Jawaharalal Nehru University, New Delhi, India (1976), Chapter 2.

15/ W. Leontief, The Structure of the American Economy, 1919-1939, Oxford University Press, New York (1951).

16/ Harry W. Richardson, op.cit. pages 8-9.

17/ At the moment of writing this work, the 1977 input-output table for the U.S. economy is in the process of construction. An unofficial version of 1977 can be obtained from the U.S. Department of Labour, Washington, D.C.

18/ Central Statistical Office (CSO), Input-Output Table for the United Kingdom, 1963, 1968 and 1972, London: HMSO.

19/ Input-Output studies of the Puerto Rican economy began as early as 1948, initiated by the Social Science Research Center of the University of Puerto Rico and supervised by W. Leontief and Amor Fosfield. The study culminated in a 22-Gosfield order total flow matrix for the fiscal year 1948. Later tables were constructed by the Puerto Rico Planning Board. The table for the year of 1963 was constructed under the supervision of Mr. Erik Homb of the CBS in Norway.

20/ P.N. Mathur and R. Bharadwaj (editors) Economic Analysis in Input-Output Framework, Input-Output Research Association, Poona, India (1965) pages 15-26.

21/ However its "neutrality" does not prevent the application of input-output analysis to practical problems like, for instance, economic impact studies, forecasting and other applications. See H.W. Richardson, op.cit., Chapter 10.

22/ For instance, in the field of International Economics, input-output analysis has been applied within the framework of comparative cost theory by Leontief, Mathur and others. In Economic Development and Planning important contributors have been made by P.N. Mathur, W. Leontief, H.B. Chenery and others. A recent book by V. Bulmer-Thomas has made valuable contributions to the understanding of problems of less developed countries, in input-output framework. See his Input-Output Analysis in Developing Countries, John Wiley and Sons Ltd., New York (1982). Regional Economics is another field where furitful applications of input-output analysis have been made by, W. Leard, P.N. Mathur, Eugene Smolensky, W. Leontief, H.W. Richardson and others. See for instance, P.N. Mathur, "Economic Implications of Transport Cost Minimization In a Dynamic

Input-Output Framework", in Fifth International Conference on Input Output Techniques, Geneva (1971), North Holland Publishing Co., Amsterdam.

23/ P.A. Samuelson, "Abstract of a Theorem Concerning Substitutability in Open Leontief Model", in T.C. Koopmans (ed.) Activity Analysis in Production and Allocation, Wiley and Sons Ltd (1951).

24/ On this subject the reader should consult, T.C. Koopman, op. cit., and G.B. Dantzing "Programming of Interdependent Activities, Part II", Econometrica (1949).

25/ Peter A. Victor, Pollution: Economy and Environment, University of Toronto Press, 1972. See also R.U. Ayres and A.V. Kneese, "Production, Consumption and Externalities", American Economic Review (June 1969).

26/ Rosenbluth, "Input-Output Analysis: A Critique", Statistiche Hefte, 9, No. 4 (1968).